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Description

The invention relates to an apparatus for maintaining a uniform mass flow rate of particulate solids and gas mixture discharged from a holding vessel apparatus to a reactor, comprising means for introducing said mixture into a receiving means having converging walls which form at least one port at the apex thereof for discharging said mixture therefrom. More in particular, this invention relates to pulverized coal discharged to a gasifier for the manufacture of synthesis gas.

Conventional coal feed systems using gravity flow of solids, such as in a coal feed to coal-fired boilers, tolerate major fluctuations in the coal mass flow rate and suspension density.

Various devices have been built for discharging substances which tend to flow easily by gravity, such as grain. While devices such as those disclosed in U.S. Patent Specifications Nos. 3,289,396, 3,367,724, 4,529,336, 3,424,352 and 4,067,623 are concerned with providing "efficient discharge" of particulate materials from bulk storage tanks and avoiding bridging and incomplete discharging from such tanks, these devices do not maintain a uniform mass flow rate of particulate solids and gas mixture discharged in a uniform manner to a receiving reactor.

The present invention is directed to overcoming this problem in the art both for uniform flow and for reliable continuous flow. The apparatus of the invention therefore is constructed such that the receiving means comprises an inner shell and a jacket surrounding the inner shell, and mounted to form a substantially enclosed space between the walls of the inner shell and said jacket, said jacket having at least one outlet port at the converging end thereof in axial alignment with the discharge port of said receiving means; and wherein a plurality of plugs is mounted in said walls, said plugs being porous to gaseous fluids and wherein one face of said plugs is exposed to said particulate solids and gas mixture, said jacket being provided with a partition within the substantially enclosed space forming at least two substantially enclosed compartments; means for selectively injecting gaseous fluid under pressure into said compartments; and means for independently controlling the flow rate and direction of said gaseous fluid under pressure at a rate sufficient to fluidize the particulate solids in proximity to said portion of porous plugs but at a rate below that which would fluidize the particulate solids located beyond the wide end of the converging walls.

It can be remarked that "Soviet Inventions Illustrated", Sections P, Q, 14.11.1984, discloses a feeder for pneumatic transport of friable material, comprising a container with a conical air-permeable bottom enclosed in a pneumatic chamber. Further, two compartments with separate gas supply and flow control

are disclosed. However, the specific apparatus of the present invention has not been disclosed.

Generation of synthesis gas occurs by partially combusting a carbonaceous fuel, such as coal, at relatively high temperatures in the range of 1000 °C-3000 °C and at a pressure range of from about 1-200 bar, in the presence of oxygen or oxygen-containing gases in a coal gasification reactor, hereinafter referred to as a gasifier. Steam, carbon monoxide, carbon dioxide and oxygen-containing gases including air, oxygen-enriched air, and oxygen are optionally diluted with nitrogen and/or other inert gases.

In the present invention, the fuel and gas mixture is discharged from a feed vessel apparatus, advantageously having multiple outlets, each outlet being in communication with at least one burner associated with the gasifier. Typically, a gasifier will have burners in diametrically opposing positions, but this is not required for this invention. Generally, the burners have their discharge ends positioned to introduce the resulting flame and the agent of combustion into the gasifier.

Of particular importance in the manufacture of synthesis gas is the uniform manner in which the particulate fuel is introduced to the burners within the gasifier. Fluctuations in the mass flow rate of coal being supplied to the burners of the gasifier are detrimental to gasifier's performance. What is needed is reliable uniform flow of coal having fluctuations less than 1-2% at a frequency range of 0.01-100 Hz. For example, such fluctuations can cause inefficient combustion of fuel within the gasifier and damaging heat fluxes to the burner face which could result in thermal stresses on the burner face. If the mass flow rate of the particulate fuel fluctuates, zones of underheating are generated next to zones of overheating in the gasifier. As a result, in the zones of underheating the fuel is not completely gasified and in zones of overheating the fuel is completely converted into less valuable products, viz. carbon dioxide and water vapour. Additionally, localized high temperatures in the gasifier could damage the refractory lining which is normally arranged at the inner surface of the gasifier wall.

Since the residence time of the coal within the reaction zone of the reactor is approximately 5 seconds or less, the coal mass flow rate should advantageously be constant over periods of this order and advantageously over shorter periods to maintain constant local conditions.

Various factors substantially affect the mass flow rate of the fuel being supplied to the burners. In particular, the discharging of the particulate fuel from a feed vessel apparatus and the transporting by conduit of the fuel from the vessel to the gasifier affect the mass flow rate of fuel to the gasifier. Specifically, fuel and gas mixtures having densities ranging from about 50-800 kg/m³ transported through a conduit having a

diameter less than 150 mm experience significant pressure drop due to the summation of various contributions such as frictional losses, restrictions, curvatures, etc. within the conduit.

The present invention utilizes a vessel having downwardly-converging walls at the lower end thereof forming a portion having plugs of porous material for aerating the solids within the vessel, and having at least one port at the apex so as to maintain a uniform mass flow rate of the solids and gas mixture discharged to a gasifier. In particular, areas located circumferentially about the outside of the porous material portion are isolated to form one or more closed compartments. Gaseous fluids are injected into each compartment at selected pressure and rate to maintain a uniform mass flow rate of a particulate solids and gas mixture to be discharged to the receiving gasifier. Furthermore, the interchangeability of porous material portions having different permeabilities provide greater flexibility for operating the process under varying conditions, such as different coal types, coal moisture content, etc. This configuration can be changed depending on the solids flow characteristics and properties.

An advantage of the present invention is that maintaining a uniform mass flow rate of a particulate solids and gas mixture to a gasifier prevents the occurrence of zones of underheating and overheating within the gasifier.

A further advantage of the present invention is the protection afforded the refractory lining within the gasifier due to the prevention of zones of underheating and overheating.

An additional advantage of the present invention is more efficient utilization of fuel in the production of synthesis gas.

Another advantage of the present invention is the capability of maintaining high suspension densities, e.g. greater than 50 to 800 kg/m³, in the transport line from the vessel to the gasifier thereby reducing the consumption of aeration and pneumatic transport gas and avoiding dilution of the synthesis gas produced in the gasifier which would make the synthesis gas a less valuable product.

Although the invention is described hereinafter primarily with reference to pulverized coal, the method and apparatus according to the invention are also suitable for reactive solids and other finely divided solid fuels which could be partially combusted, such as lignite, anthracite, bituminous, brown coal, soot, petroleum coke, shale, tar sands, and the like. Advantageously, the size of solid carbonaceous fuel is such that 90 per cent by weight of the fuel has a particle size smaller than 100 mesh (A.S.T.M.).

Additionally, the present invention can be used for both granular, pulverized, and powdered solids such as resins, catalysts, fly ash, and electrostatic precipitator fines, and the like.

The invention will now be described in more detail by reference to the accompanying drawings, in which:

Fig. 1 illustrates a coal gasification system employing an embodiment of this invention;

Fig. 2 is a cross-section of the embodiment taken along line II-II of Fig. 1;

Fig. 3 is an isometric view of the liner of the present invention;

Fig. 4 is another alternate embodiment of the present invention; and

Fig. 5 is still another alternate embodiment of the present invention.

The drawings are of a process flow type in which auxiliary equipment, such as pumps, compressors, cleaning devices, etc. are not shown. All values are merely exemplary or calculated.

Referring to Fig. 1, an apparatus for maintaining a uniform mass flow rate of a particulate solids and gas mixture discharged from a holding vessel apparatus, such as a feed hopper 11 operated at elevated pressures of 1-200 bar, via a conduit 40 to a receiving reactor, such as a gasifier 9, generally includes means for introducing the mixture, such as an inlet port 10, into the feed hopper 11. The feed hopper 11 directs the material into generally cone-shaped receiving means shown generally at 7 and described more particularly with reference to Fig. 2.

Referring now to Fig. 2, the receiving means 7 may be lined with a liner or inner shell 8 to be more particularly described with reference to Fig. 3. The liner 8 has converging walls 12 forming an included angle of less than about 150 degrees, in particular less than about 90 degrees, and converging toward at least one port 17 formed at the apex thereof for discharging the mixture therefrom.

The receiving means 7 comprises a jacket 13 which surrounds the liner 8 and is mounted to form a substantially enclosed space, or manifold, between the walls 12 of the liner 8 and the jacket 13. The jacket 13 has at least one outlet port 15 at the lower end thereof which is in axial alignment with the discharge port 17 of the liner 8 for discharging particles therefrom.

Means for isolating areas, advantageously first and second areas 18, 19, respectively, located outside and circumferentially about substantially adjacent portions of porous plugs 14 of walls 12, such as a partition 22 within the substantially enclosed space between the jacket 13 and the walls 12, forms at least two substantially enclosed compartments. The jacket 13 includes means for selectively injecting gaseous fluid under pressure into first and second areas 18, 19, respectively, such as inlet ports 23A, 23B, and 24A, 24B, respectively, from pressurized fluid sources 20, 21, respectively. Although sources 20, 21 are shown as separate sources, it is recognized by those skilled in the art that gaseous fluid may be supplied from the same source.

The compartments formed within the substantially enclosed space between the walls 12 and the jacket 13 permit gaseous fluids, possibly having different densities, such as nitrogen or other inert gas and synthesis gas which is mainly carbon monoxide, hydrogen, and water, to be selectively injected into the compartments. The gas injected from source 20 into the first area 18 may be more, equal, or less dense than the gas injected from source 21 into second area 19. Advantageously, the gas injected into area 18 would be inert and the gas injected into area 19 would be particulate-free synthesis gas. The gas injected into area 18 would flow upwards and could be vented to control the pressure in the feed hopper 11 whereas the gas injected into the area 19 flows downward and is transported to the gasifier 9.

Referring now to Fig. 3, the liner 8 is advantageously made of a heavy, solid material such as stainless steel or alloy 20 and contains a plurality of holes such as 32 in the walls 12. The holes 32 are countersunk to receive and retain plugs shown generally at 14 of Figs. 2, 3A and 3B. The plugs 14 are comprised of inserts 16 made of porous material which may be metallic or non-metallic, such as sintered powdered metal, woven stainless steel, or porous ceramic, depending upon the operating conditions and type of coal used in the process. The arrow A in Figs. 3A and 3B represents gas flow. Inserts 16 are held in place by means of a retainer ring 27 which also allows for differential thermal expansion. The porous material of insert 16 has a selected permeability. The porous material of the insert 16 facilitates the uniform distribution of gaseous fluid injected from pressurized sources 20, 21 into the liner 8 and prevents bridging of the particulate solids discharged from the liner 8 via discharge port 17.

The pore size of the porous material and the type of porous material of the insert 16 is based on, among other factors, the type of coal or fuel used and the temperature of operation. To allow greater operating flexibility to use various types of coal requiring differing pore sizes, the liner 8 is advantageously interchangeable with another liner having plugs 14 of a different permeability than the first liner 8.

Sufficient pressure drop over each plug should be maintained to ensure uniform flow over all the plugs.

Furthermore, introduction of the gaseous fluid into the pores of the porous material of the insert 16 imparts a pressure restriction to the gaseous fluid thus ensuring an even flow distribution of the fluid throughout the plugs 14 of the walls 12 of the liner 8. Similarly, the porous material serves to control the bulk density of the mixture within the liner 8 and the discharge rate of the mixture leaving the hopper 11 via port 17.

The configuration of the insert 16 of Fig. 3A presents a smoother surface to the particulate solids

whereas the configuration of Fig. 3B is simpler from a manufacturing standpoint.

The holes 32 (and plugs 14) are arranged to provide proper aeration for differing particulate matter and characteristics thereof. For example, the holes 32 of the liner 8 may be arranged in three general zones of openness, 33, 34 and 35, where the zone 33 is 3% open, the zone 34 (bridging zone) is 10% open and the zone 35 is 5% open. The entire liner 8 may have approximately 200 holes 32, the diameter of each being on the order of 140 mm. The size of the plugs, configuration of the plugs and mechanical sealing depend also on the mechanical strength criteria, which are related to operating conditions.

The flow rate and direction of the gaseous fluid, advantageously nitrogen and synthesis gas, injected under pressure into the first and second areas 18, 19, respectively, are controlled by using flow controllers 25A, 25B, 26A and 26B, respectively, at a rate sufficient to aerate the particulate solids in proximity to the plugs 14 of walls 12, but at a rate below that which would fluidize the particulate solids located above the plugs 14. It is undesirable to inject the gases at a rate sufficient to fluidize the particles above the inserts 16 as is typically done in conventional systems, because it results in more inert gas diluting the synthesis gas produced in the gasifier 9 and thus yielding a less valuable product.

The slip velocity above the aeration cone 8, i.e. the relative superficial velocity between the gas and the coal within the hopper, should be less than 50% of the fluidization velocity and in particular near zero. Also, fluidization of the particles increases fluctuations of the mass flow rate of solids discharged from the coal feed hopper 11.

Additionally, the flow rates of the gaseous fluid from sources 20, 21 should not exceed the terminal falling velocity of the solids contained within the feed hopper 11. Terminal falling velocity is defined as the velocity at which the drag forces on a solid particle due to the flow of gases upward equals the downward force on the particle due to gravity. If the flow rates of the gases exceed the terminal falling velocity, then the solids will be discharged via the vent 50 rather than the discharge port 17.

Advantageously, the flow rates of these gases from sources 20 and 21 are independently controllable which permits the separate control of the amount of gas flowing upward and the amount of gas flowing downward relative to the flow of the coal.

For example, for a uniform mass flow rate of particulate solids and gas mixture of 2000 kg/hr having a suspension density of 450 kg/m³ discharged from the feed hopper 11, the rate of injecting nitrogen in the first area would be approximately 100 kg/hr. Should this rate be exceeded then the suspension density would be less than 450 kg/m³ and the synthesis gas produced in the gasifier 9 would be diluted by the nit-

rogen from source 20. Additionally, should this rate be somewhat less than the selected rate then the suspension density would be substantially higher than 450 kg/m³. Depending on the material and operating conditions, this situation could lead to less than stable flow.

Furthermore, the gaseous fluid may be injected in various directions and elevations to control the pressure and velocity profile which exists at the discharge port 17. Depending on the physical properties of the particles being transported, it may be necessary to have more than two compartments or to inject gas above the compartmented region.

This selective injection provides for separate control of the mixture density within the feed hopper 11 and the discharge density of the mixture leaving the hopper 11 via the outlet port 15. As a result, the discharge port 15 of the hopper 11 is much smaller than conventional technologies for suspension densities of 200-500 kg/m³ preferred in the present invention.

The diameter of the discharge port 17 in the present invention is about 4 mm to about 150 mm for a solids and gas mixture having a suspension density of about 200-500 kg/m³. This diameter is larger than the maximum bridging diameter of the aerated particulate solids to prevent bridging of the solids as they exit the discharge port 17. Conventional coal feed systems using gravity flow of solids assisted by aeration to break up bridging typically have a suspension density of less than 200 kg/m³ at the discharge outlet of the feed hopper and a corresponding feed vessel apparatus discharge port diameter of greater than about 150 mm. Diameters of the discharge port 17 greater than about 150 mm for a given mass flow rate used in the present invention are not desirable because either the velocity or suspension density would fall below the desired limits thus resulting in fluctuations of the mass flow rate of the coal and gas mixture to the gasifier 9.

Additionally, the smaller discharge port 17 diameter of the present invention, in conjunction with the compartmented injection of gaseous fluids, acts like a fluidic valve to control the particulate discharge rate and thereby eliminates the need for troublesome valves in transport hardware between the discharge of the hopper 11 and the gasifier 9.

Furthermore, the present invention may be provided with means for venting gas from the upper end of the hopper 11, say via port 50, for the purpose of maintaining an upward flow of gas through the solids in the feed hopper 11 of approximately 2 mm/sec and thereby eliminate local bridging of the solids and provide smoother flow to the discharge port 17.

Alternatively, the present invention may incorporate liners 8A and 8B located inside the feed hopper 11, rather than at the lower end of the hopper 11, as shown in Figs. 4 and 5, respectively. An advantage to the embodiment shown in Fig. 4 is that the transport

line 40 from the feed hopper 11 to the gasifier 9 would be shorter for plant configurations in which the burners of the gasifier are elevated with respect to the feed hopper. A shorter transport line 40 provides more uniform flow of the coal to the burners of the gasifier 9.

Another advantage of the alternate embodiments shown in Figs. 4 and 5, for the multiple outlet feed hopper 11, is that the geometry of the hopper 11 is substantially simplified as a result of the liners 8A and 8B being located inside the hopper 11.

It would be recognized by one skilled in the art that references made with respect to the direction of flow of the gases and coal particles within the liner 8 of the embodiment described in Fig. 1 would be reversed when referring to the liner 8A shown in Fig. 4 since the liner 8A is inverted with respect to the first containing means 8 shown in Fig. 2.

The foregoing description of the invention is merely intended to be explanatory thereof, and various changes in the details of the described method and apparatus may be within the scope of the appended claims without departing from the spirit of the invention.

Claims

1. An apparatus for maintaining a uniform mass flow rate of particulate solids and gas mixture discharged from a holding vessel apparatus (11) to a reactor (9), comprising:

means for introducing said mixture into a receiving means (7) having converging walls (12) which form at least one port (17) at the apex thereof for discharging said mixture therefrom;

the receiving means (7) comprising an inner at least partially porous shell (8) and a jacket (13) surrounding the inner shell (8), and mounted to form a substantially enclosed space between the walls (12) of the inner shell (8) and said jacket (13), said jacket having at least one outlet port (15) at the converging end thereof in axial alignment with the discharge port (17) of said receiving means (7);

said jacket also being provided with a partition within the substantially enclosed space forming at least two substantially enclosed compartments;

means (20, 21) for selectively injecting gaseous fluid under pressure into said compartments; characterized by a plurality of plugs (14) being mounted in said walls (12), said plugs (14) being gaseous fluids and one face of said plugs being exposed to said particulate solids and gas mixture,

and means (25A, 25B, 26A, 26B) for independently controlling the flow rate and direction

of said gaseous fluid under pressure at a rate sufficient to fluidize the particulate solids in proximity to said portion of porous plugs but at a rate below that which would fluidize the particulate solids located beyond the wide end of the converging walls (12),

said means comprising means for

injecting a first gaseous fluid having a selected density into a first compartment; and means for

injecting a second gaseous fluid having a density less than said first gaseous fluid into a second compartment.

2. The apparatus as claimed in claims 1 or 2, characterized in that said plugs (14) are arranged in zones (33, 34, 35) of different openness of said inner shell (8).

Patentansprüche

1. Vorrichtung zum Aufrechterhalten einer gleichmäßigen Massenflußrate eines Gemisches aus teilchenförmigen Feststoffen und Gas, welches von einer Zwischen- bzw. Haltegefäßvorrichtung (11) zu einem Reaktor (9) abgegeben wird, umfassend:

eine Einrichtung zum Einführen des Gemisches in eine Aufnahmeeinrichtung (7), die konvergierende Wände (12) hat, welche an ihrer Spitze wenigstens eine Öffnung (17) bilden zum Abgeben des Gemisches aus der Öffnung, wobei die Aufnahmeeinrichtung (7) eine innere wenigstens teilweise poröse Hülle (8) und einen die innere Hülle (8) umgebenden Mantel (13) aufweist und so angebracht ist, daß ein im wesentlichen eingeschlossener Raum zwischen den Wänden (12) der inneren Hülle (8) und dem Mantel (13) gebildet ist, der Mantel wenigstens einen Auslaßöffnung (15) an seinem konvergierenden Ende in axialer Ausrichtung mit der Abgabeöffnung (17) der Aufnahmeeinrichtung (7) hat und weiterhin mit einer Trennwand innerhalb des im wesentlichen eingeschlossenen Raums versehen ist, welche mindestens zwei im wesentlichen eingeschlossene Abteile bildet; und

eine Einrichtung (20, 21) zum wahlweisen Injizieren von unter Druck stehendem gasförmigen Fluid in die genannten Abteile; gekennzeichnet durch

eine Mehrzahl von Stopfen (14), die in den Wänden (12) angebracht und gegenüber gasförmigen Fluiden porös sind, wobei eine Fläche der Stopfen dem Gemisch aus teilchenförmigen Feststoffen und Gas ausgesetzt ist; und

eine Einrichtung (25A, 25B, 26A, 26B) zum unabhängigen Steuern der Strömungsrate

und der Strömungsrichtung des unter Druck stehenden gasförmigen Fluids zu einer Rate, die ausreichend ist, die teilchenförmigen Feststoffe nahe dem Abschnitt der porösen Stopfen zu fluidisieren, jedoch in einer Rate unterhalb derjenigen, bei der die teilchenförmigen Feststoffe, die sich jenseits des weiten Endes der konvergierenden Wände (12) befinden, fluidisiert werden,

wobei die genannten Einrichtungen Mittel zum Injizieren eines ersten gasförmigen Fluids, welches eine ausgewählte Dichte hat, in ein erstes Abteil, und

Mittel aufweisen zum Injizieren eines zweiten gasförmigen Fluids, welches eine Dichte hat, die kleiner als die Dichte des ersten gasförmigen Fluids ist, in ein zweites Abteil.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Stopfen (14) in Zonen (33, 34, 35) unterschiedlicher Offenheit bzw. unterschiedlichen Öffnungsgrades der inneren Hülle (8) angeordnet sind.

Revendications

1. Un dispositif pour maintenir un débit massique uniforme d'un mélange de particules solides et de gaz déchargé d'un appareil à réservoir de retenue (11) dans un réacteur (9), comprenant :

des moyens pour introduire le mélange dans un moyen de réception (7) ayant des parois convergentes (12) qui forment au moins un orifice (17) à leur sommet pour déchargement du mélange ; le moyen de réception (7) comprenant une enveloppe intérieure (8) au moins partiellement poreuse et une chemise (13) entourant l'enveloppe intérieure (8) et montée de manière à former un espace substantiellement clos entre les parois (12) de l'enveloppe intérieure (8) et la chemise (13), cette chemise ayant au moins un orifice de sortie (15) à son extrémité convergente en alignement axial avec l'orifice de sortie (17) du moyen de réception (7) ; la chemise étant pourvue aussi d'une cloison à l'intérieur de l'espace substantiellement clos formant au moins deux compartiments substantiellement clos ; des moyens (20, 21) pour injecter sélectivement un fluide gazeux sous pression dans les compartiments ; caractérisé par une multiplicité de bouchons (14) montés dans les parois (12), ces bouchons (14) étant poreux pour les fluides gazeux et une face des bouchons étant exposée au mélange de particules solides et de gaz et des moyens (25A, 25B, 26A, 26B) pour régler indépendamment le débit et la direction du fluide gazeux sous pression à un débit suffisant pour fluidiser les particules solides à proximité de

ladite portion des bouchons poreux, mais à un débit inférieur à celui qui fluidiserait les particules solides situées au-delà de l'extrémité large des parois convergentes (12), ces moyens comprenant des moyens pour injecter un premier fluide gazeux ayant une masse volumique choisie dans un premier compartiment ; et des moyens pour injecter un second fluide gazeux ayant une masse volumique inférieure à celle du premier fluide gazeux dans un second compartiment.

2. Le dispositif selon la revendication 1, caractérisé en ce que les bouchons (14) sont disposés dans des zones (33, 34, 35) de pénétrabilité différente de l'enveloppe intérieure (8).

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FIG. 1

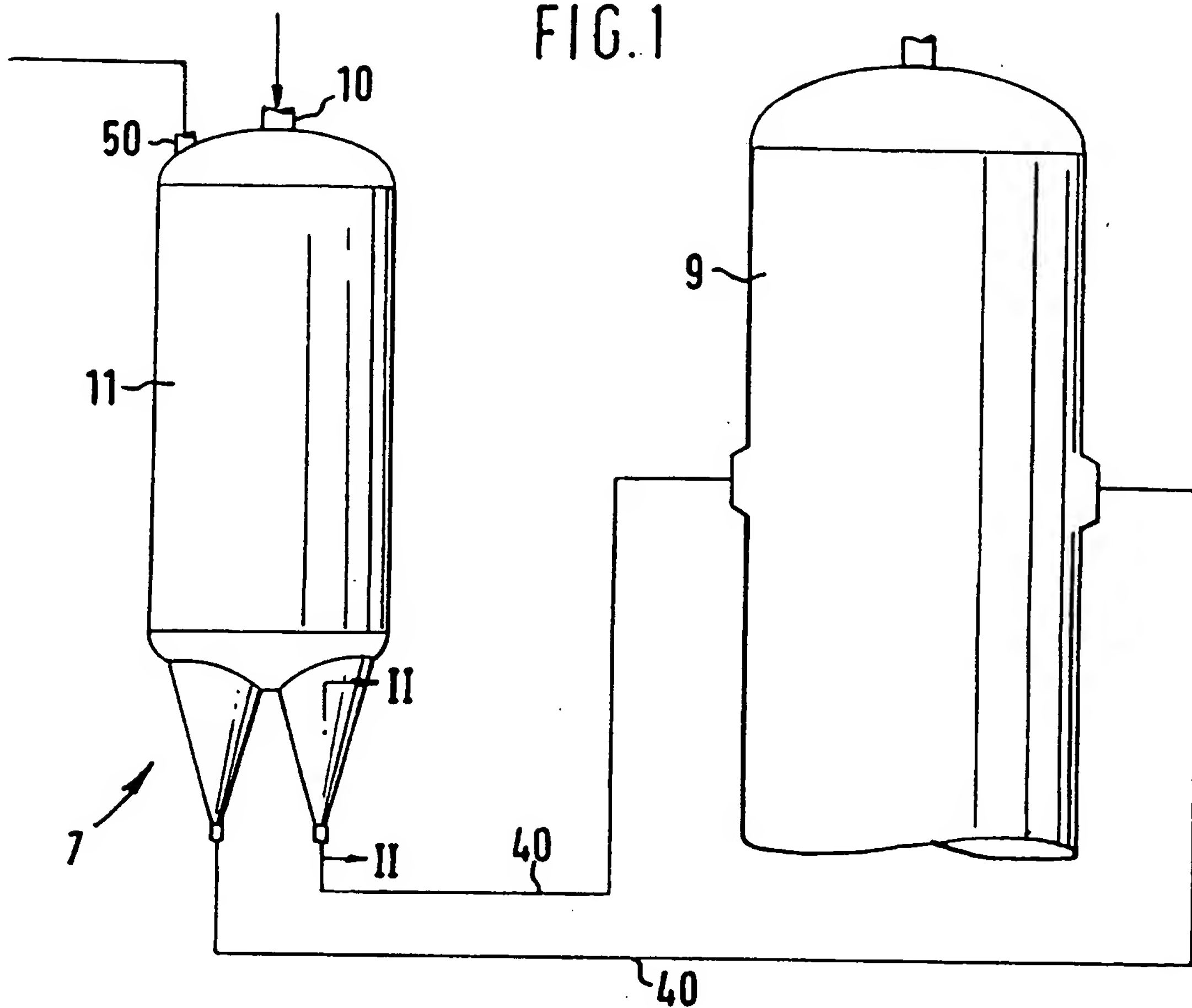
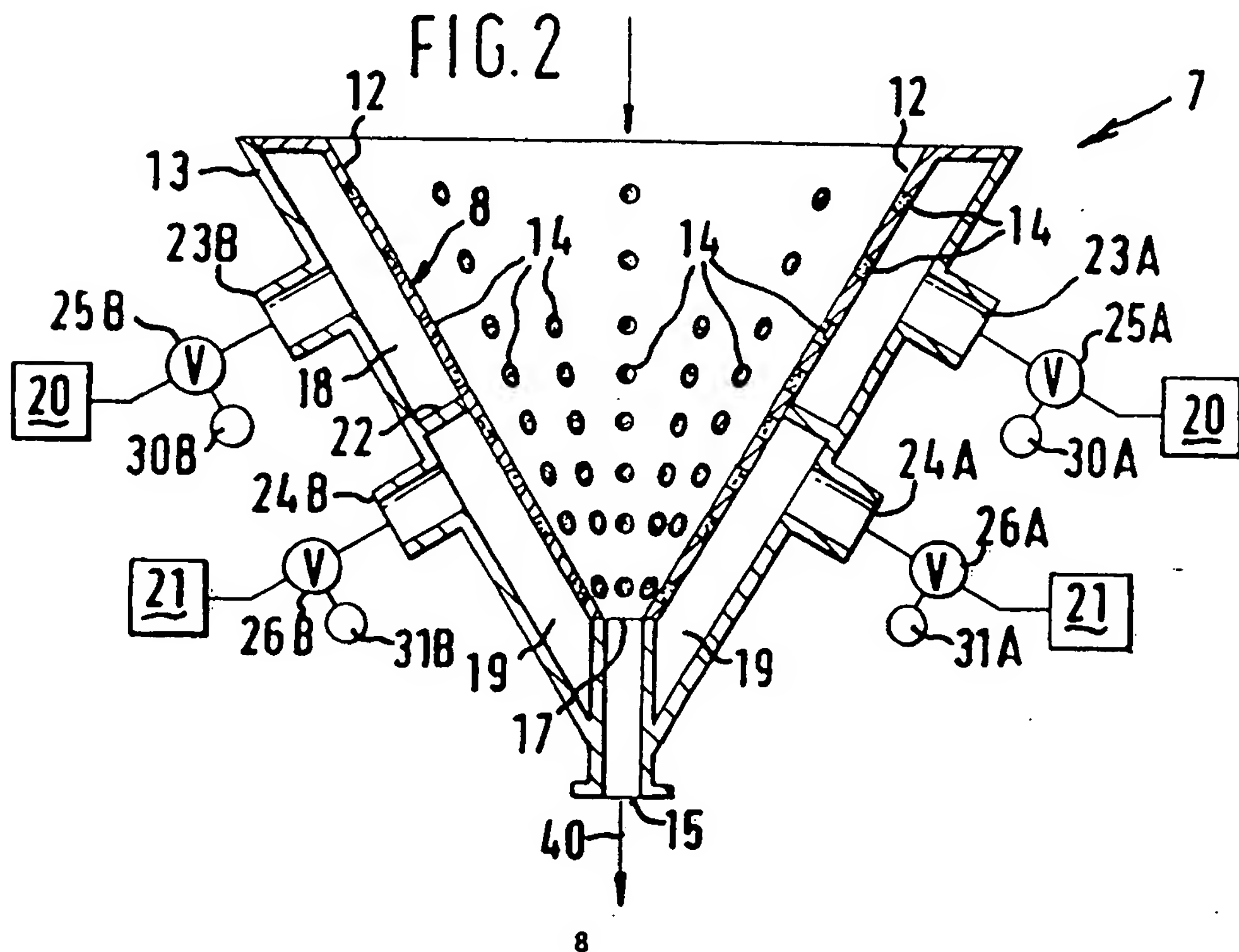
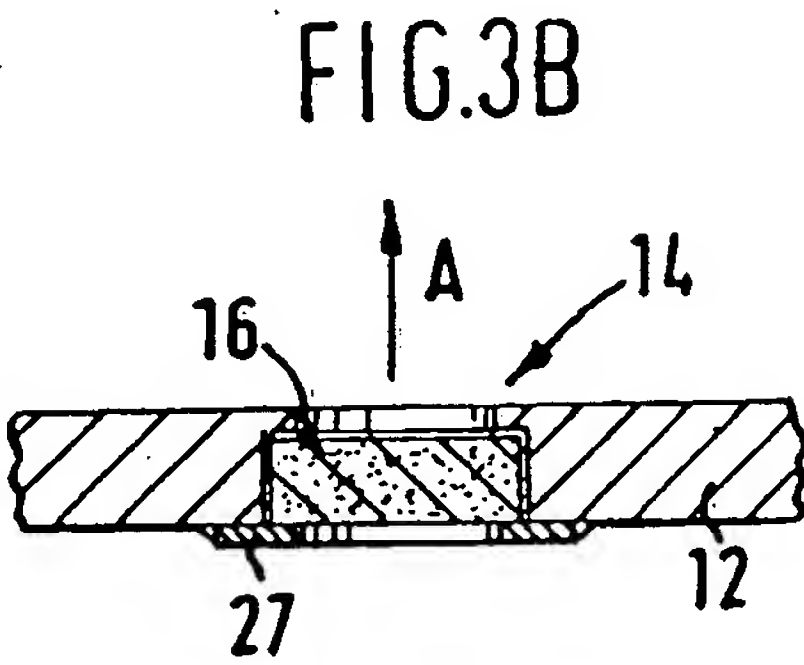
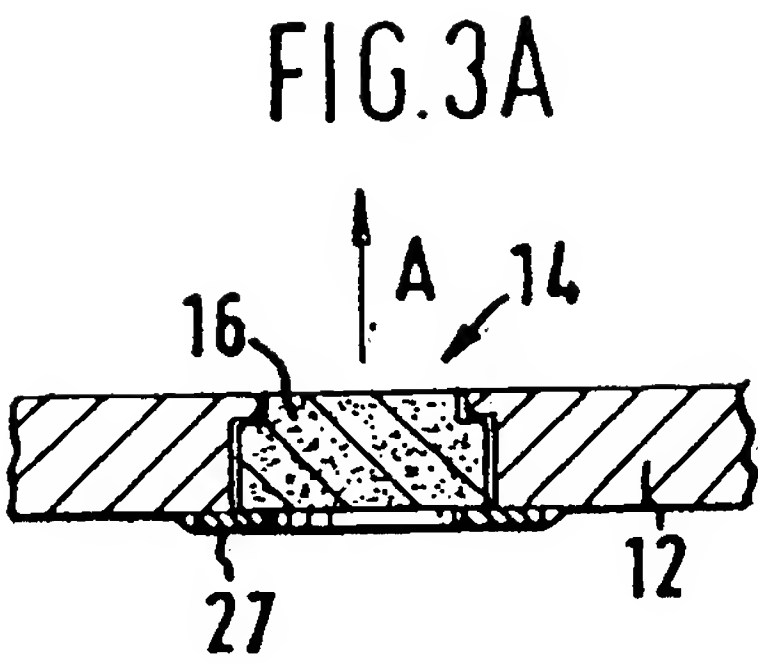
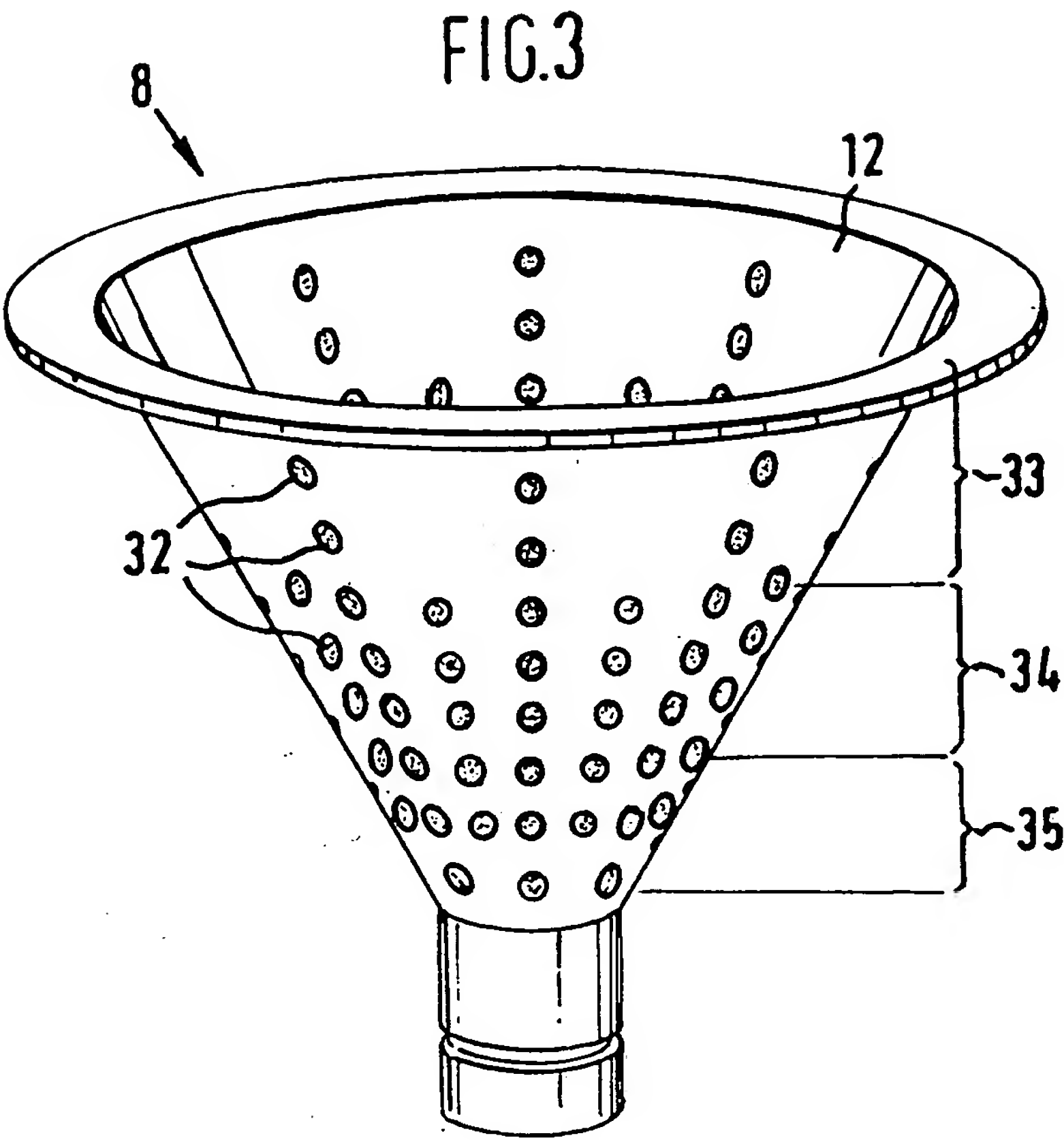


FIG. 2





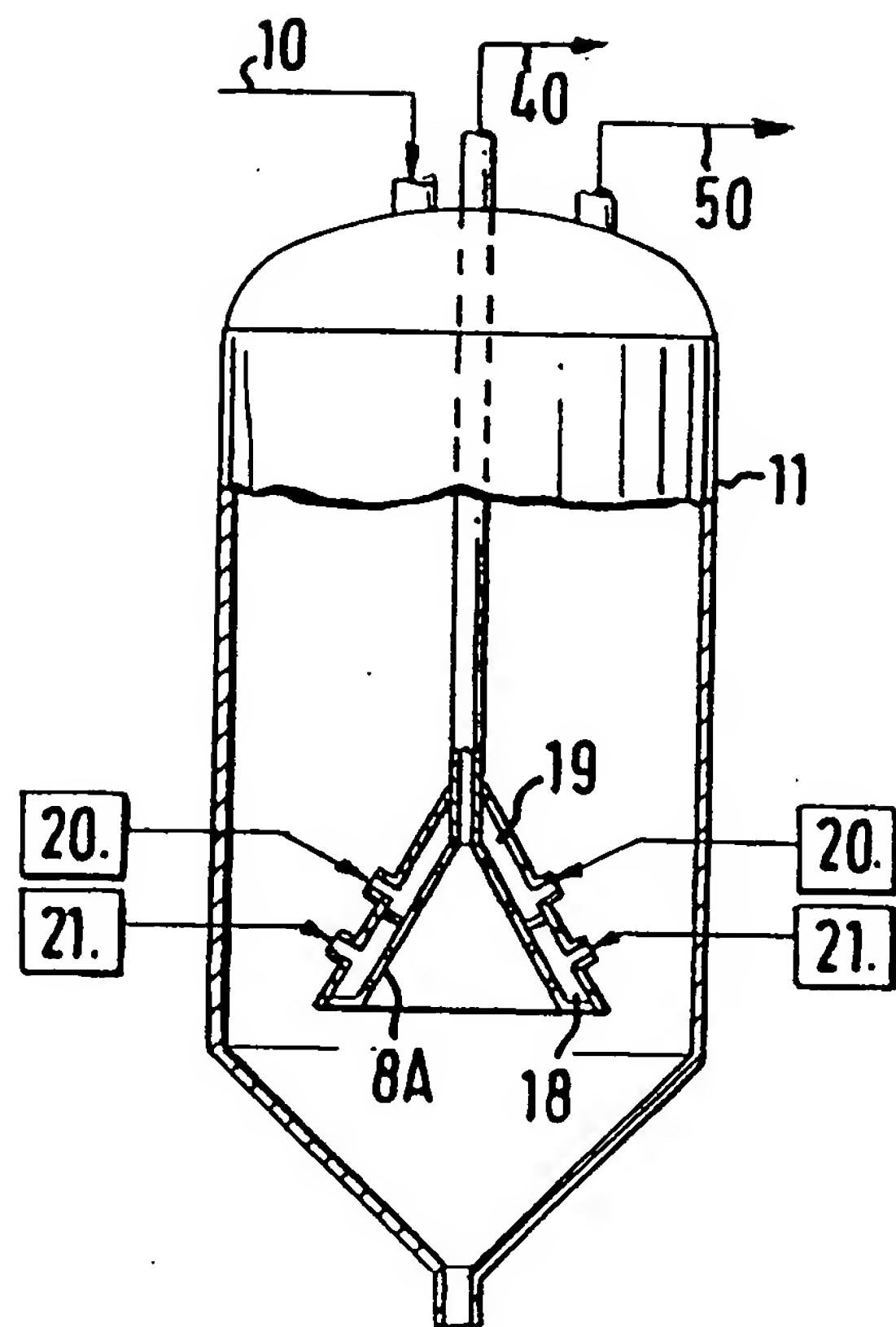


FIG. 4

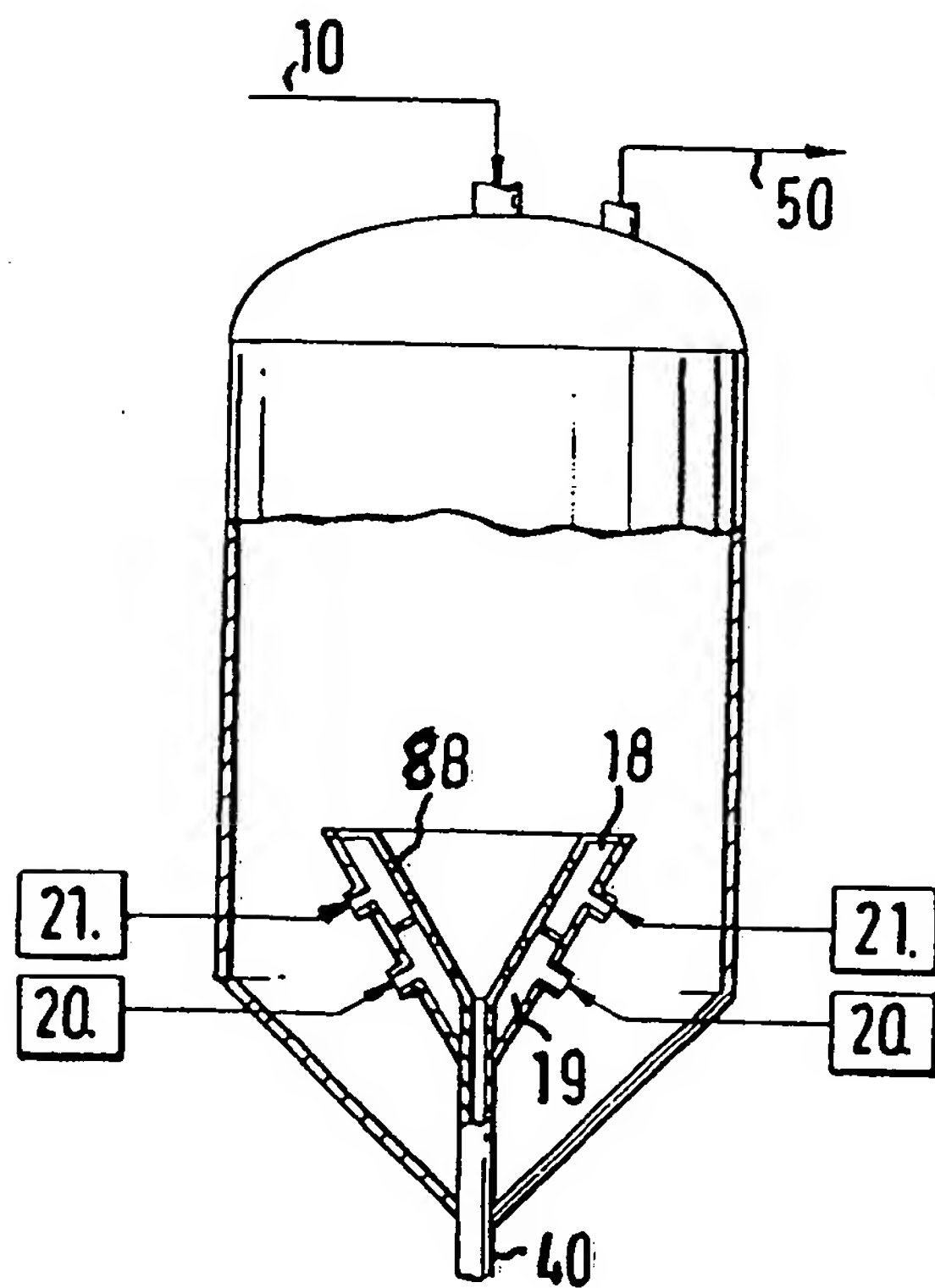


FIG. 5